July 10, 2023

News and notes

Before going on to discuss how geology has affected the fate of Bahrain, here are some news items I thought were interesting.

Science in the News

- Texas anatomy professor who also works as a pastor is fired after teaching students sex is determined by X and Y chromosomes, causing four to walk out of his class: 'I just teach basic biology'.
- A Systematic Review of Autopsy Findings in Deaths after COVID-19 Vaccination; Daily Skeptic summary here.

Research

- Oceanography: Phytoplankton responses to dust addition in the Fe–Mn co-limited eastern Pacific sub-Antarctic differ by source region.
- Variation in bridgmanite grain size accounts for the mid-mantle viscosity jump; Phys.org summary here.
- Progressive lawsonite eclogitization of the oceanic crust: Implications for deep mass transfer in subduction zones; Phys.org summary here.
- Partitioning of Fe2+ and Fe3+ between bridgmanite and silicate melt: Implications for redox evolution of the Earth's mantle; Phys.org summary here.
- Hadean mantle oxidation inferred from melting of peridotite under lower-mantle conditions; Phys.org summary here.
- Ore geology, polymetallic sulfides present in mid-ocean ridges: Sulfide metallogenic model for the ultraslow-spreading Southwest Indian Ridge; Phys.org summary here.
- I/Pu reveals Earth mainly accreted from volatile-poor differentiated planetesimals; Eureka Alert summary here.
- Why the day is 24 hours long: The history of Earth’s atmospheric thermal tide, composition, and mean temperature; Eureka Alert summary here.
- Enhanced inner core fine-scale heterogeneity towards Earth’s centre; Eureka Alert summary here.
- No evidence of supracrustal recycling in Si-O isotopes of Earth’s oldest rocks 4 Ga ago; Eureka Alert summary here.
- Hyperspectral imaging sediment core scanning tracks high-resolution Holocene variations in (an)oxygenic phototrophic communities at Lake Cadagno, Swiss Alps.

- Reconstruction of the proto-type basin and tectono-paleogeography of Tarim Block in the Mesozoic.
- Editorial: (Paleo-) Pacific plate subduction tectonics and related magmatism and mineralization.

Paleontology

- Amber and the Cretaceous Resinous Interval; Phys.org summary here.
- Pliocene fossils support a New Zealand origin for the smallest extant penguins; Phys.org summary here.
- Fossils reveal how ancient birds molted, could explain why modern birds survived while other dinosaurs died; research papers here and here.
- Raptorial appendages of the Cambrian apex predator *Anomalocaris canadensis* are built for soft prey and speed; Phys.org summary here.

Glaciers and Climate Change

- Constraining the contribution of the Antarctic Ice Sheet to Last Interglacial sea level; Phys.org summary here.
- Abrupt change in tropical Pacific climate mean state during the Little Ice Age; Phys.org summary here.
- Empirical assessment of the role of the Sun in climate change using balanced multi-proxy solar records; Phys.org summary here.

Environmental Geology and Hydrogeology

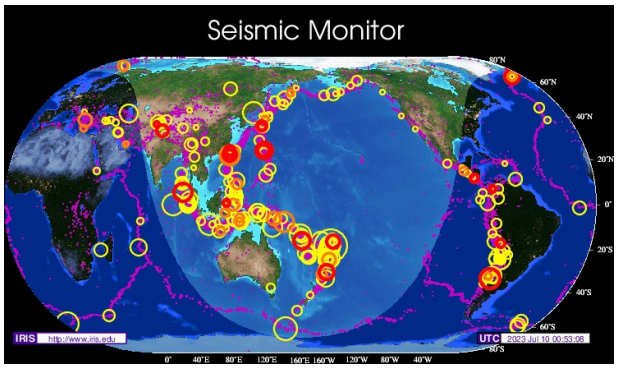
- Per- and polyfluoroalkyl substances (PFAS) in United States tapwater: Comparison of underserved private-well and public-supply exposures and associated health implications; Daily Mail summary here.
- The Murray-Darling Basin shows why the 'social cost of water' concept won't work.
- Removing pharmaceuticals from wastewater: Effective bioremediation of clarithromycin and diclofenac in wastewater by microbes and *Arundo* donax L.
- Radionuclide contamination: ^{137}Cs and isotopic ratios of Pu and U in lichens and mosses from Russian Arctic areas.
- Groundwater springs formed during glacial retreat are a large source of methane in the high Arctic; Eureka alert summary here.

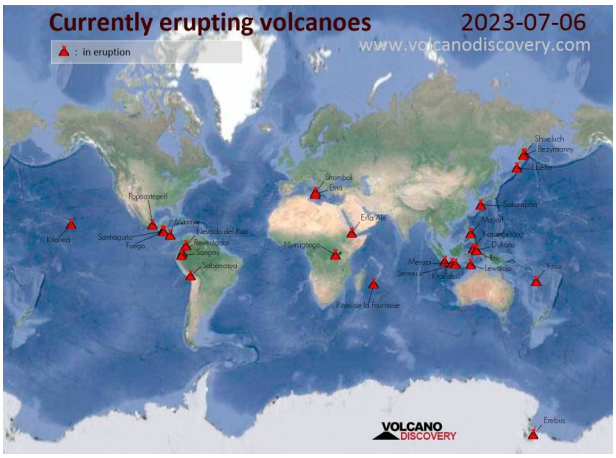
Mining and Energy

- Helium Evolution Announces Farm-in Partner Confirmed to Drill Five New Wells in the Next Nine Months.

- Exploration techniques: Well log prediction while drilling using seismic impedance with an improved LSTM artificial neural networks.
- More exploration technique research: Application of a new hydrocarbon detection technique with phase decomposition in carbonate reservoir of the Pre-Caspian Basin.
- Source rock research: Geochemical and gas bearing characteristics of the marine-continental transitional Longtan shales in southern Sichuan, China.
- Geothermal energy: The number of production wells affects the heat extraction performance of an enhanced geothermal system: insights from engineering-scale 3D THM coupling numerical simulations.

Volcanoes, Earthquakes and Geohazards





Seismic Monitor **Active Volcano Map**

- From the United States Geological survey (USGS): Volcano Watch — International volcano scientist training course returns to Hawaii.
- Editorial: Patterns and trends of time–space evolution of volcanism, from local to global.
- Volcano eruptions are notoriously hard to forecast. A new method using lasers could be the key; related: Discrete magma injections drive the 2021 La Palma eruption.
- Physical and chemical characteristics of active sulfur flows observed at Lastarria volcano (northern Chile) in January 2019; Phys.org summary here.
- Possible magmatic CO2 influence on the Laacher See eruption date; Eureka Alert summary here.
- Limited sulfur degassing and muted environmental impact of Ontong Java Plateau lavas.
- Why earthquakes happen all the time in Britain but not in Ireland.
- Landslides: Medieval demise of a Himalayan giant summit induced by mega-landslide; Phys.org summary here.

July 10, 2023

Geology and the Fate of Societies – Bahrain

The Kingdom of Bahrain is an island nation on west side of the Persian Gulf, east of Saudi Arabia and northwest of Qatar. In addition to the man island, Bahrain Island, the country includes some 50 natural islands and an additional 33 artificial islands and is connected to Saudi Arabia by the King Fahd Causeway. According to the United States Central Intelligence Agency's World Factbook, the islands of Bahrain encompass some 760 km^2. The CIA'S 2023 estimate for the population of Bahrain is 1,553,886 people. The ethnic makeup of the country is: Bahraini citizens 46%, Asians 45.5%, other Arabs 4.7%, Africans 1.6%, Europeans 1%, and other 1.2%. The capital and largest city in Bahrain is Manama.

Figure 1 – Bahrain
Credit: Directorate of Intelligence, CIA, public domain

Figure 2 – Satellite Image of Bahrain
Credit: Google Earth

Geology

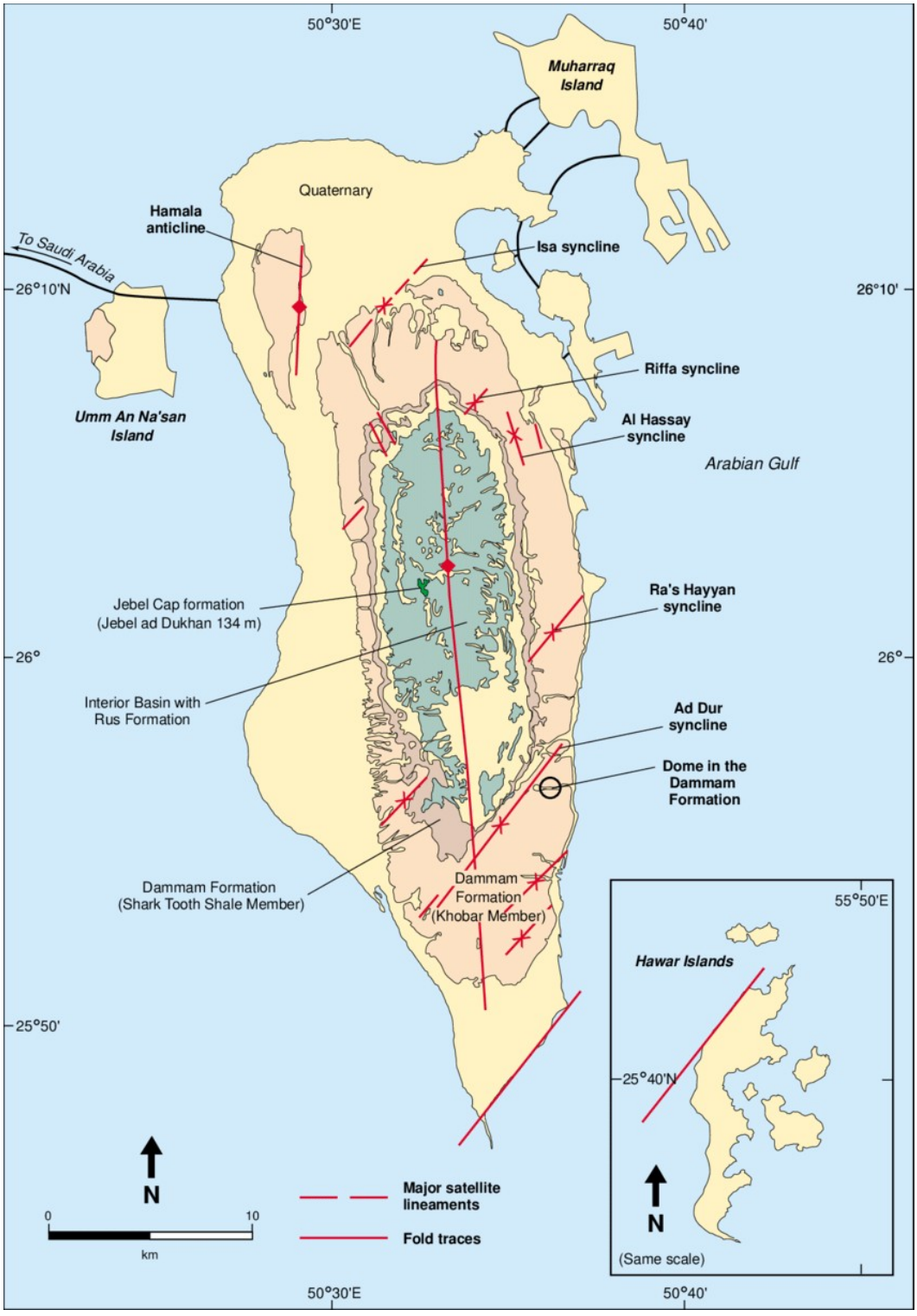


Figure 3 – Geologic Map of Bahrain with Structural Trends
Credit: Figure 19 in Botz et al, 2005

Bahrain consists of a large anticline at depth, the Awali Field, with an associated series of synclines that in turn are part of the larger geology of the Persian Gulf.

The surface geology of Bahrain which consists entirely of Cenozoic aged formations. The main formations include:

- Quaternary aged sabkha deposits, coastal salt flats, together with gravel, sand and silt deposits;
- The Miocene aged Dam Formation (also called the Jebel Cap Formation): mudrocks, sandstones, and limestones;
- The Eocene aged Dammam Formation: carbonates (limestones and dolomites); and
- The Eocene Rus Formation: carbonates and evaporites.

Beneath the Cenozoic deposits at Bahrain are complex Mesozoic (Cretaceous, Jurassic and Triassic) deposits that contain most of the petroleum and natural gas deposits exploited in Bahrain. The Bahrain or Awali Field, measures approximately 15 kilometres long and 5 kilometres wide. It is a geologically complex field and consists of 16 oil reservoirs and 4 Khuff gas reservoirs in addition to deep pre-Khuff reservoirs. The reservoirs are mainly carbonates with fluids varying from shallow tarry oil in Aruma at 1000' to deep non-associated dry gas in the Khuff and pre-Khuff formations at depth of 9000' and deeper. In 2017-18, explorers found shale deposits containing oil that may be commercially exploitable. As well, deep Paleozoic deposits may contain exploitable natural gas deposits.

The Phanerozoic deposits of Bahrain sit upon basement rocks of the Arabian Shield that were formed during the Idsas Orogeny that occurred during late Precambrian and early Cambrian.

Resources

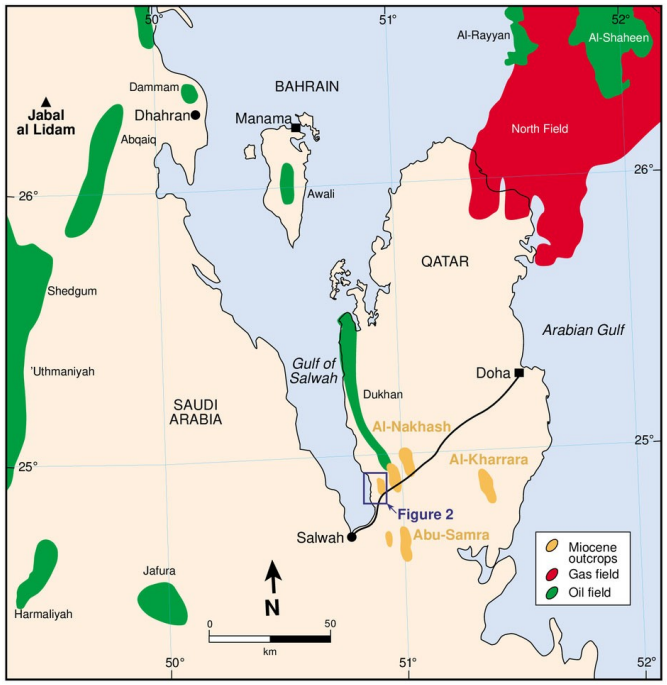
Agriculture and Food Resources

Figure 4 – Date Palm, Manama, Bahrain
Credit: Ahmed Rabea, Creative Commons Attribution-Share Alike 2.0 Generic license

Agriculture accounts for only 1% of Bahrain's economy and employs 2% of Bahrain's work force. Limited water resources, saline soils and an arid climate limit agriculture. Alfalfa, for animal fodder, is the major crop. However, the 3,000 farmers in Bahrain also grow dates, figs, mangos, pomegranates, melons, papayas, water turnips, potatoes, and tomatoes. They also produce poultry and dairy products for the local market. Most food consumed in Bahrain is imported.

As an island nation, fishing and shellfish harvesting are important sources of food and other products. Shellfish, especially oysters for pearls, have been a long established activity in Bahrain.

Mineral Resources



Petroleum and natural gas are the major mineral resources in Bahrain. In 2018, according to the USGS Mineral Yearbook, Bahrain produced 71,000,000 barrels of oil and 14,790 million cubic metres of natural gas. Ammonia and urea fertilizer are alos produced from natural gas in Bahrain.

Petroleum production in Bahrain began in 1932 and involved some interesting characters such as Major Frank Holmes. Holmes, a New Zealand geologist began exploration activities there in 1923 after securing a concession for oil exploration in exchange for installing water wells. Oil production began after the initial oil discovery in 1932.

Figure 5 – Oil and Natural Gas Fields in the Vicinity of Bahrain
Credit: Figure 1 in Al-Saad& Ibrahim, 2002

Climate

Bahrain has an arid, desert climate – hot and dry. The weather pattern includes a cooler season from December to February and a hot season from April to October, and a very hot period from May to mid-October. March and November are transitional months, warm but without excesses.

History and Geopolitics

Bahrain was the home of the Bronze Age Dilmun culture, a mercantile people who made a living trading various goods with the peoples around the Persian Gulf. Their great wealth attracted the attention of the empires of the Middle East including the Akkadian, Assyrian, and Persian empires. Arab followers of the Prophet Muhammad conquered the land in AD 628 and Bahrain remained part of successive Arab and Persian polities until 1783, when the Al-Khalifa family took over rule of the island. In the 19th century the Al-Khalifa sheiks entered into a deal with the British Empire whereby Bahrain would be a British protectorate, with the Al-Khalifa family in charge of local affairs. In 1971, Bahrain became independent of the British and they threw their lot in with United States, who took on the role of Bahrain's "protector".

Figure 6 – King Hamad bin Isa Al Khalifa
Credit: Julian Carroll, public domain

Bahrain's geopolitical situation explains why the Al-Khalifa family have chosen to put themselves under the protection of outside powers, first the British empire and then the United States. Bahrain has two powerful neighbours: Saudi Arabia and Iran. Bahrain has religious and cultural links with both nations.

Saudi Arabia dominates the Arabian Peninsula and could easily absorb Bahrain if there was no outside opposition. Also of note is that the Al-Khalifa family are Sunni Muslims as is the Saud family that rules in Saudi Arabia.

Iran has historical claims on Bahrain going back to pre-Islamic times. Most of the Muslim population of Bahrain are Shia, as are most of the population of Iran.

Steering a course between the two regional powers has been essential for the Al-Khalifa family if they wish to retain control of the country. Having the help outside powers, like Britain and the United States, has been important in the past and remains so today for the current head of the family, King Hamad bin Isa Al Khalifa.

The potential conflict between Bahrain's Sunni rulers and Shia subjects will be problem for the King in the foreseeable future. When things are going well economically, it is less of a problem. However, should there be a serious economic downturn, The Sunni/Shia split in the country could be exploited by ambitious troublemakers. One scenario is an attempt to overthrow of the Al-Khalifa family in an "Arab Spring" event. The role of the American CIA in the Arab Spring can't be very comforting to the rulers of Bahrain, especially as they have looked to the United States for help rather than trouble.

This brings up another possible change in Bahrain's political alignments: if the United States is becoming unreliable or even dangerous to Bahrain's rulers, maybe it's time to make other arrangements? The growing power in the world is China, and they are in diplomatic conversation with the rulers of Bahrain. The two countries are already trading partners. In 2021 China exported exported $1.36B in products to Bahrain and Bahrain exported exported $365M worth of product to China. A real advantage to the rulers of Bahrain in their dealings with China is that the Chinese are uninterested in lecturing anyone on human rights, a policy they describe as mutual respect. The Al-Khalifa family won't jeopardize their relationship with China if they take severe measures to keep order, the Chinese don't care as long as the trade flows. We can expect further bilateral cooperation between China and Bahrain as American influence in the region declines.

Another potential conflict in Bahrain is the presence of large numbers of foreign workers. There seems to be two classes of these people. The first are the foreign technical experts, mostly from Western countries but also educated people from other Muslim countries. The second class are manual labourers, mostly

from poorer Muslim countries. In recent years, Bahrain has been laying off foreign workers whenever they can be replaced with local Bahraini citizens. So far, there has not been any civil disturbance from this policy. What could cause problems is if the home countries of the foreign workers refuse to let them come home, for example, on the grounds that they have been away too long to be considered citizens of their original home countries. Angry, desperate people could cause all sorts of trouble and can be willing recruits for mischief makers. Yet another headache for the Al-Khalifa family.

Finally, since Bahrain consumes more food than they produce locally, trade is absolutely vital to their survival. This is an old story at Bahrain, but needs to said to put their situation into context.

That kind of wraps up my look at Bahrain. If any of this interests you some more, follow up on the links.

Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.